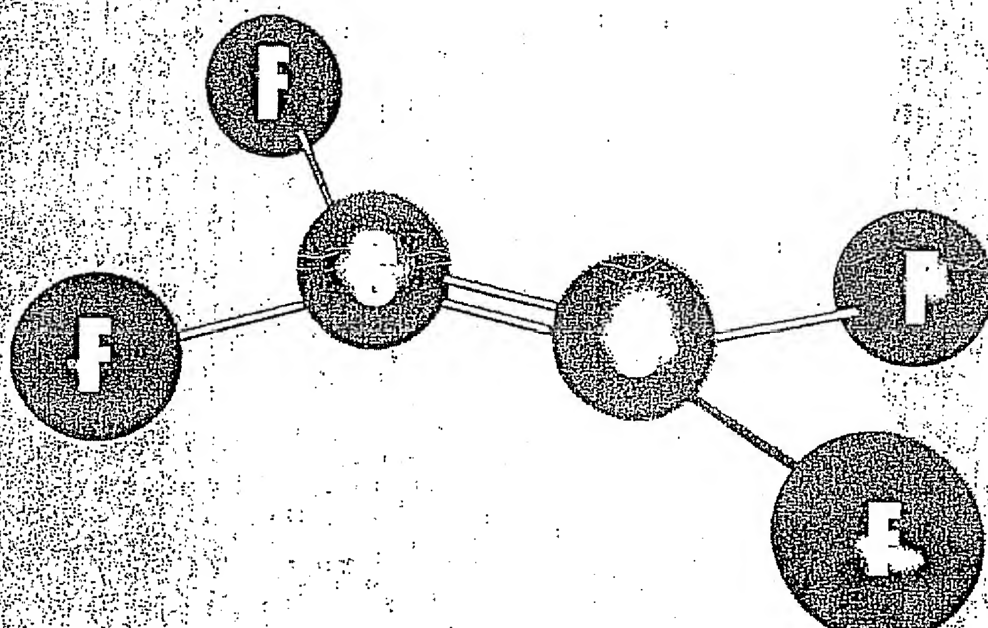
PDL HANDBOOK SERIES

Fluoroplastics

Volume 1
Non-Melt Processible Fluoroplastics

The Definitive User's Guide and Databank



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The apparent density of the resin determines the maximum value of compression ratio and therefore the maximum mold length. Equation 7.3 shows the theoretical value of compression ratio as the ratio of theoretical height of the resin in the mold and the preform height. PTFE powder is compacted during handling and charging of the mold and, therefore, its apparent density increases. Height H_F is smaller than H_T because a given weight of the resin assumes a lower height in the mold than it would have if it had not been compacted under the force of its own weight.

Eq. (7.3) $$(C.R.)_T = \frac{H_T}{H_P}$$

H_T = Filled height without compaction, mm

Equations 7.2 and 7.3 can be used to calculate the actual filled height and theoretical maximum required height of the mold, if the preform height and the compaction ratio of the resin are known. The actual mold is designed to a height between the H_F and H_T.

Equation 7.3 can be rearranged to obtain Eq. 7.4, in which S is the surface area of the cross-section of the mold and W is the weight of the resin being molded. The numerator and denominator of the right side of Eq. 7.4 represent the definition of preform density and apparent density, respectively.

Eq. (7.4) $$(C.R.)_T = \frac{\dfrac{W}{H_P S}}{\dfrac{W}{H_t S}}$$

Eq. (7.5) $$(C.R.)_T = \frac{\rho_P}{\rho_T}$$

where: ρ_P = Preform density, g/cm^3

ρ_T = Apparent powder density, g/cm^3

Preform density is typically about 1.9 g/cm^3 for a fine cut PTFE powder with an apparent density of 450 g/liter (0.45 g/cm^3). A typical value for compression ratio for this resin is 3.2. The maximum value for this resin is given by substituting for values in Eq. 7.5.

$$(C.R.)_T = \frac{1.9}{0.45} = 4.2$$

The mold length has to be 3.2–4.2 times the height of the tallest billet expected to be made; a 1.5 meter tall billet would require a mold that is 4.8–6.3 m long. Extensions can be added to the mold to obtain the desired height as long as the joint between the extension and the main body of the mold are smooth; otherwise stress concentration may lead to cracking of the billet. Mold diameter is determined by resin shrinkage, which means that each mold is designed for a specific resin since each has a specific shrinkage value. The word *shrinkage* refers to the shrinkage of the part after sintering has been completed. Usually the initial reference is the corresponding mold dimension in the calculation of shrinkage.

7.3.1.2 Presses

Hydraulic presses are recommended for preform production. Important elements of a press are smooth pressure application, maximum opening ("daylight"), ram stroke, flatness and levelness of the platens, and tonnage. A programmable press allows smooth application and removal of pressure, which is critical to producing a good part. Jerky and uneven motion of the ram will result in nonuniform application of pressure to the resin resulting in cracking during sintering. Figure 7.6 shows a typical preforming press. The tonnage of the press determines the maximum diameter of the preform. The typical maximum required preform pressure is 60 MPa for unfilled resin and 100 MPa for filled resin.

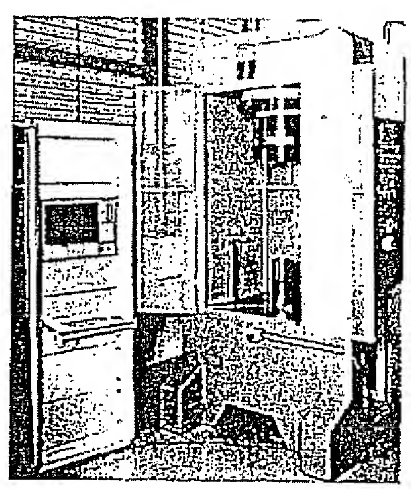

Figure 7.6 An automatic press. *(Courtesy DuPont.)*

Table 12.25. Filled PTFE Compounds of ICI[15]

Property	FC-100-15 (15% glass fiber)	FC-100-25 (25% glass fiber)	FC-110-30 (30% glass fiber)	FC-140-15 (15% Graphite)
Bulk Density, g/l	500	515	530	460
Tensile Strength, MPa	21	15	15	14
Break Elongation, %				
Preforming Pressure, MPa	50	70	70	50
Fabrication Methods	General Molding	General Molding	General Molding	General Molding

Table 12.26. Filled PTFE Compounds of ICI[15]

Property	FC-150-25 (60% Powdered Coke)	FC-160-60 (60% Bronze)	FC-180-50 (50% Stainless Steel)	FC-200-25 (25% glass fiber)
Bulk Density, g/l	450	1050	850	530
Tensile Strength, MPa	11	14	14	10.3
Break Elongation, %				
Preforming Pressure, MPa	70	70	70	
Fabrication Methods	General Molding	General Molding	General Molding	Ram Extrusion

Table 12.27. Filled PTFE Compounds of PTFE Compounds, Inc.[16]

Compound	PTFE Compounds Description	Tensile Strength (PSI)	Tensile Elongation (%)	Specific Gravity
15% Glass Low Flow	15 FG LF	3100	300	2.20
15% Glass Free Flow	15 FG FF	2900	270	2.20
25% Glass Low Flow	25 FG LF	2700	260	2.22
25% Glass Free Flow	25 FG FF	2400	240	2.22
15% Glass 5% MoS_2 Low Flow	15FG 5M LF	2800	270	2.23
15% Glass 5% MoS_2 Free Flow	15FG 5M FF	2500	240	2.23
10% Graphite Low Flow	10 GR LF	2900	270	2.11
10% Graphite Free Flow	10 GR FF	2500	240	2.11
15% Graphite Low Flow	15 GR LF	2600	220	2.10
15% Graphite Free Flow	15 GR FF	2200	200	2.10
23% Carbon 2% Graphite Low Flow	23C 2GR LF	2100	70	2.08
23% Carbon 2% Graphite Free Flow	23C 2GR FF	1900	50	2.08
25% Carbon Low Flow	25 C LF	2200	100	2.04
25% Carbon Free Flow	25 C FF	2000	80	2.04
60% Bronze Low Flow	60 BZ LF	2500	150	3.85
60% Bronze Free Flow	60 BZ FF	2300	110	3.85
55% Bronze 5% MoS_2 Low Flow	55BZ 5M LF	2200	140	3.70
55% Bronze 5% MoS_2 Free Flow	55BZ 5M FF	2000	100	3.70

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